Climate Change and Water Supply Security:
Managing Groundwater to Increase Drought Resilience

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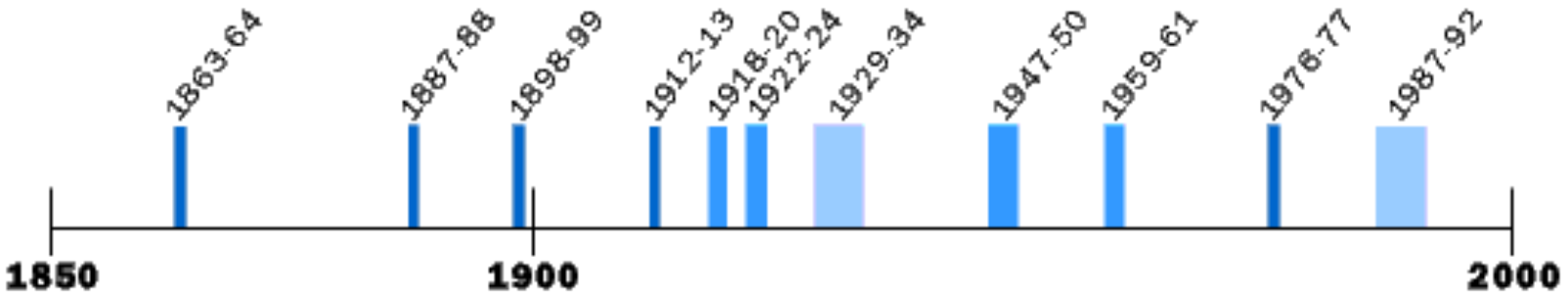
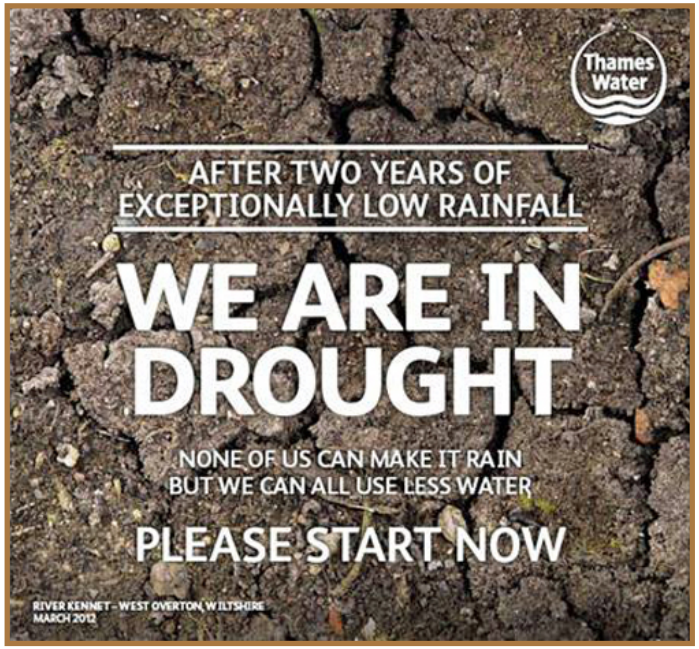
California Droughts: 1850-2000



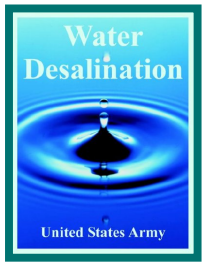
To reduce drought vulnerability, the primary strategy is to curtail water use ***after*** a drought occurs



And Generate More Supply

Recycled water

Desalination



Caution!

Increase Water Supply During Dry Years

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In Wet Years, Extra Water Can Lead to More Development

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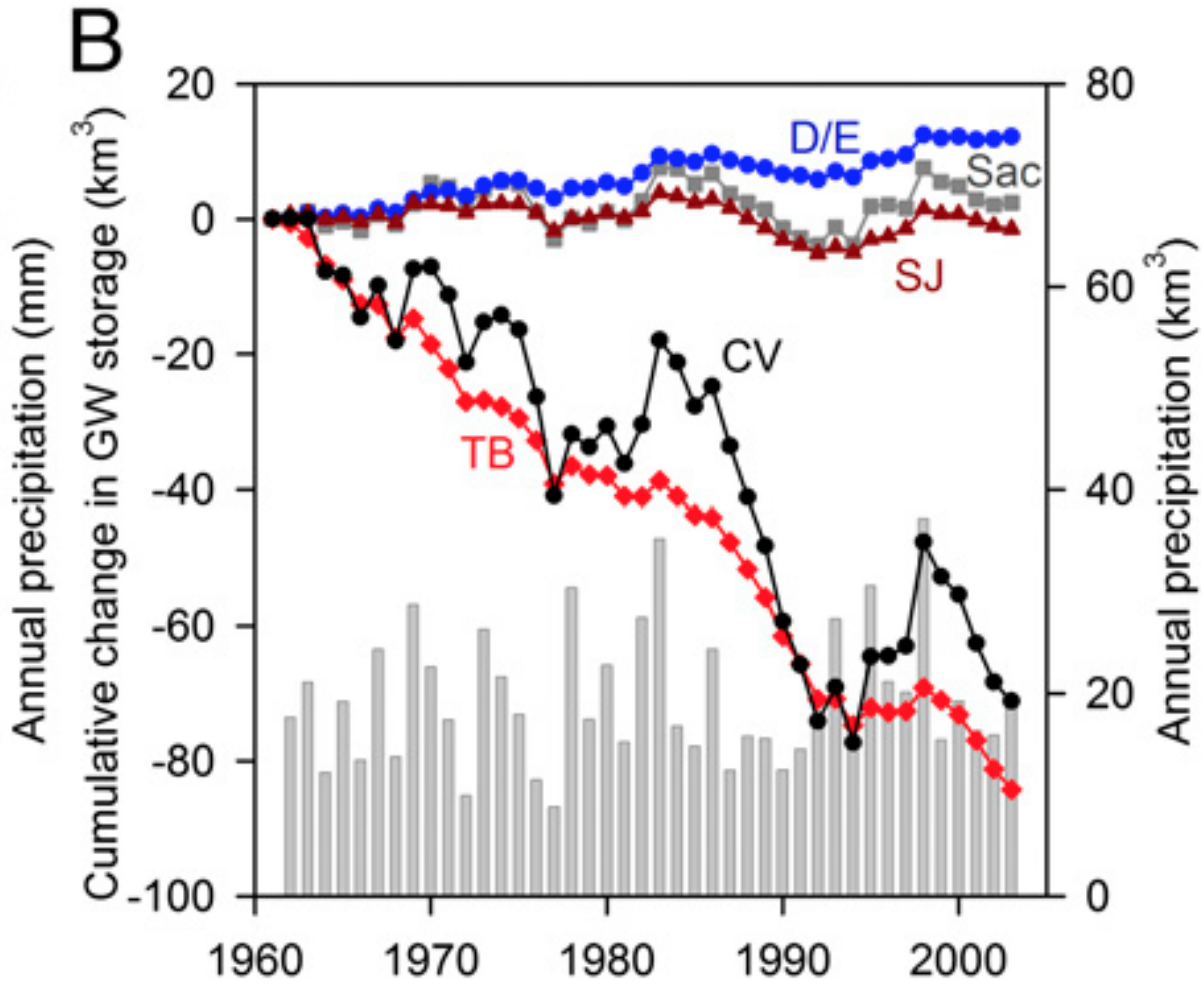
No Reserve
and
Hardening of Demand Strategies

↓

Increased Vulnerability in Future Droughts



Trends in Groundwater Depletion in the Central Valley Aquifers
After the Completion of the Central Valley and State Water Projects

PNAS-2012-Scanlon-1200311109

Overdraft leads to:

Higher pumping costs , Subsidence , Loss of supply
Water quality degradation , Environmental impacts

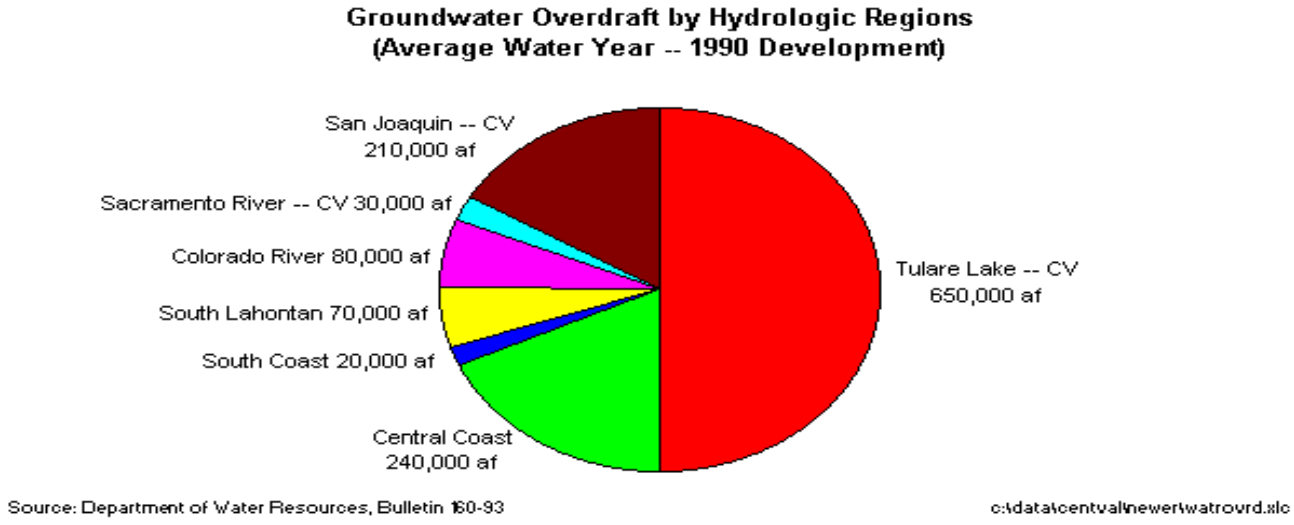
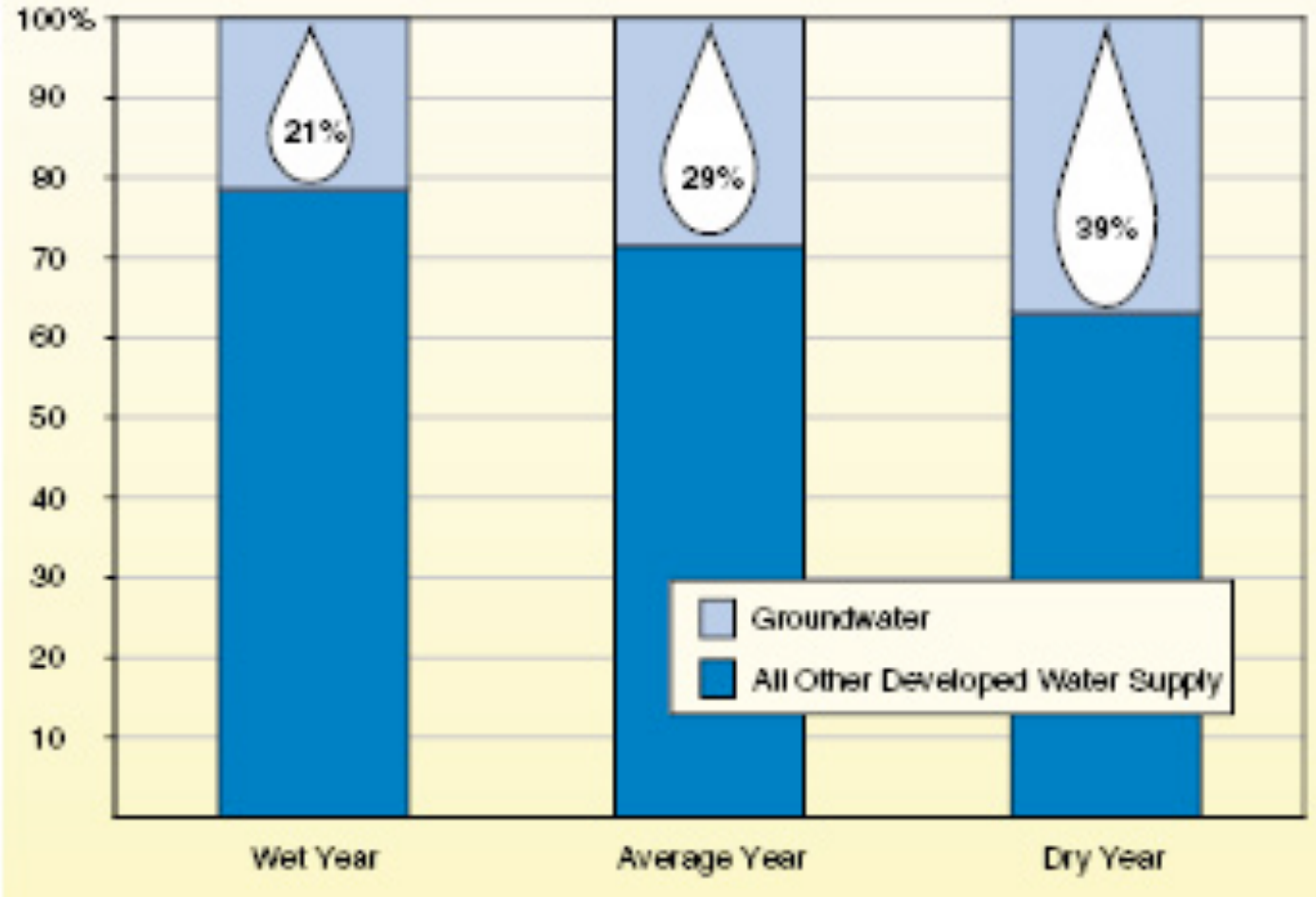


Figure 1

Groundwater Is Major Contributor to California's Water Supply, More So in Dry Years



How can California communities *proactively* adapt to the extreme droughts projected under climate change?

"..it never failed that during the dry years the people forgot about the rich years, and during the wet years they lost all memory of the dry years. It was always that way."

John Steinbeck

Local Groundwater Drought Reserves

Serve as a buffer during an extreme drought

Less energy intensive

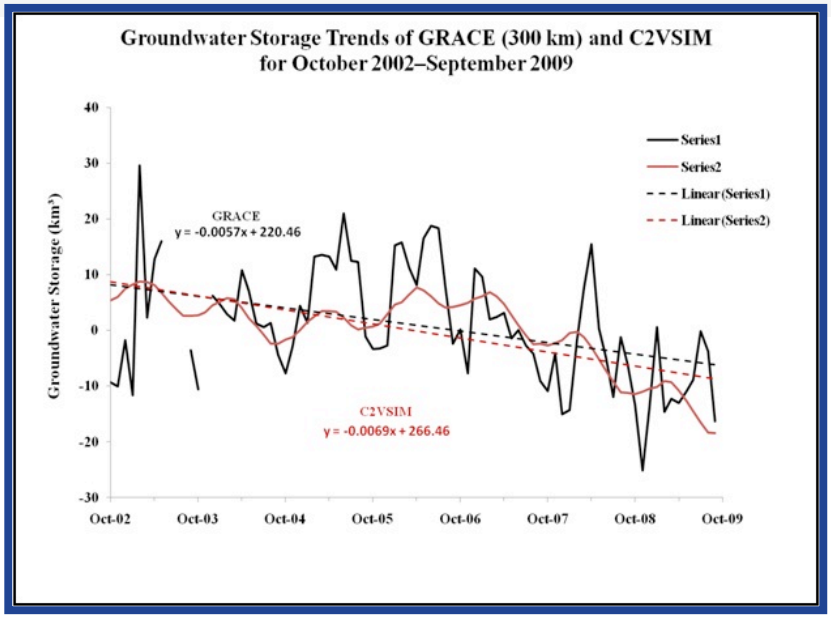
Reduce overdraft impacts

Support groundwater dependent ecosystems

How does our approach differ from current groundwater banking?

Local sources of water - Stored locally
Used for local communities

Focus on recovering groundwater levels to avoid further declines during a drought



Groundwater Storage Trends Oct. 02 - Oct. 09

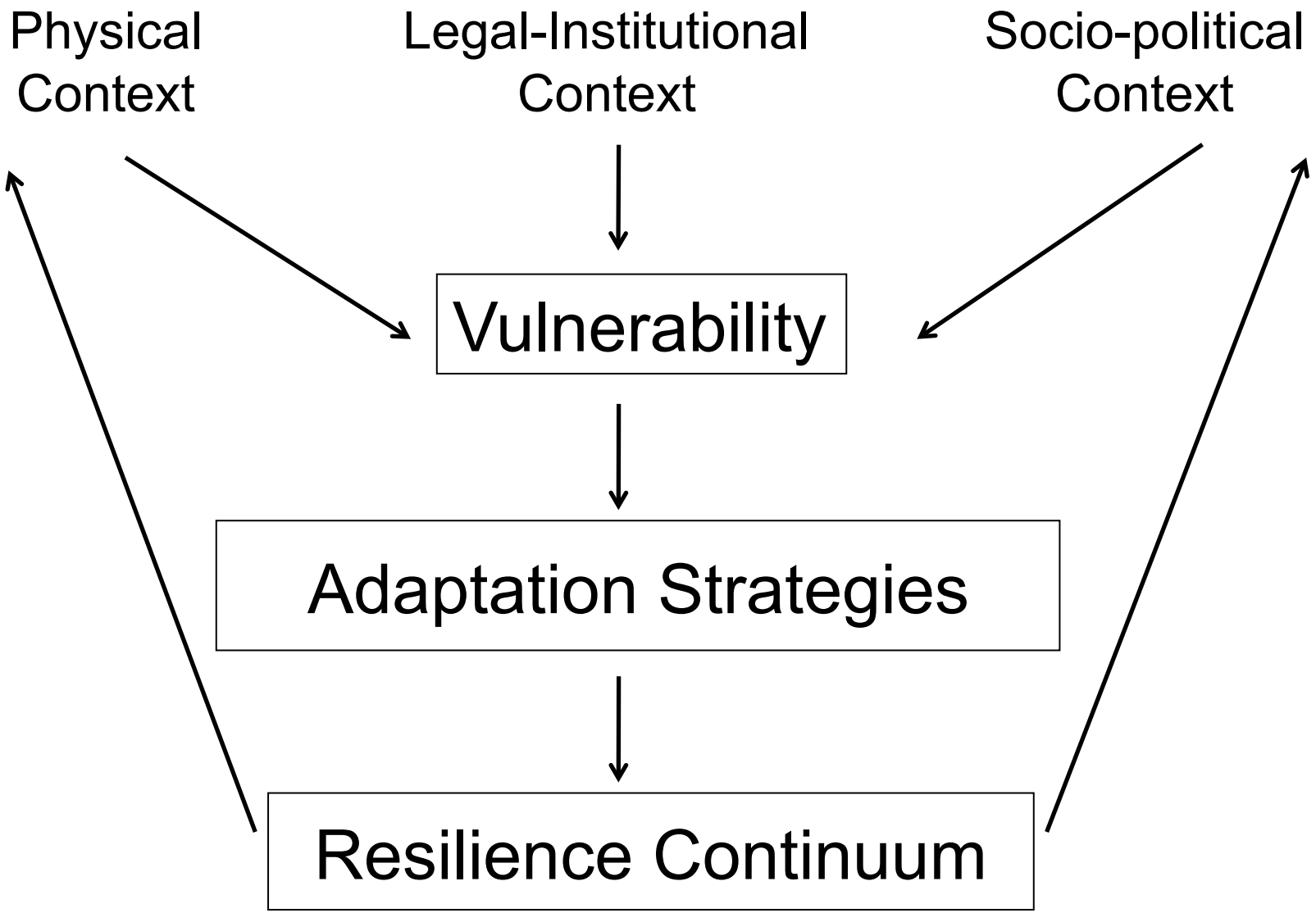
Our Approach

General and site-specific factors that affect drought resilience

Tools to develop a local groundwater drought reserve

Case Studies

Factors That Affect Drought Resilience



Legal – Institutional Context

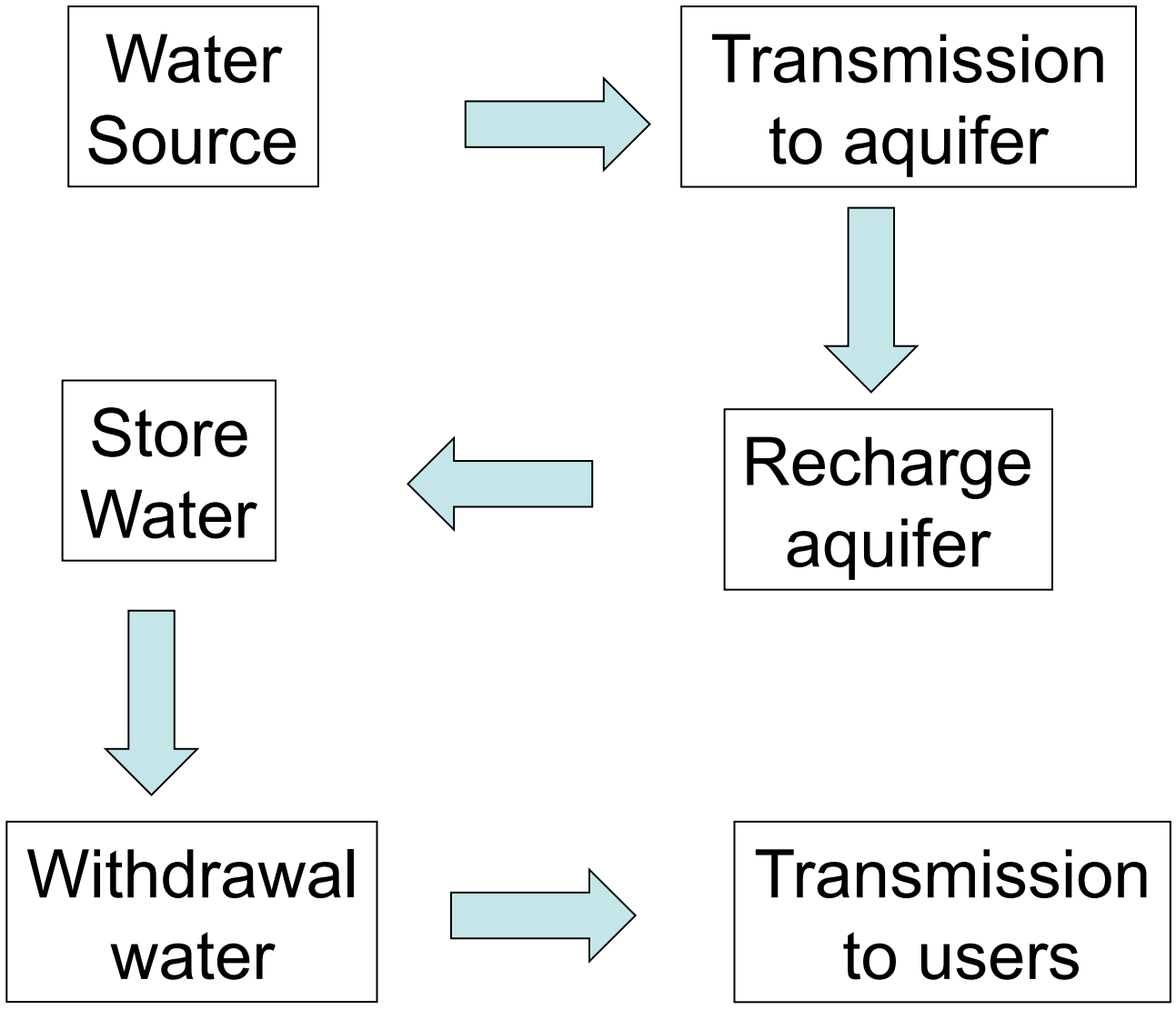
No State Permit System for Percolating Groundwater

Overlying Landowners
Correlative Rights Doctrine

Local Agencies are Primary Managers of Groundwater

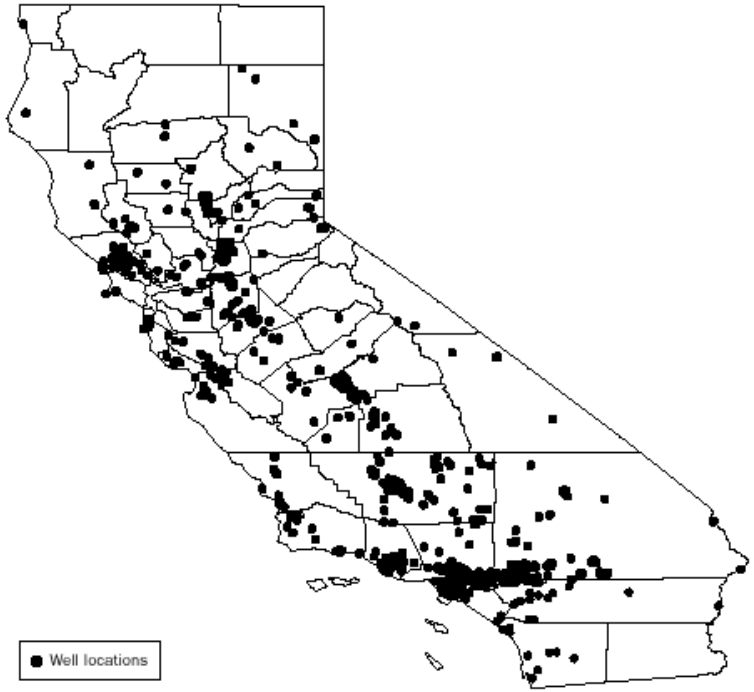
Endangered Species Act
Reasonable Use Doctrine
Public Trust Doctrine
CA Water Code

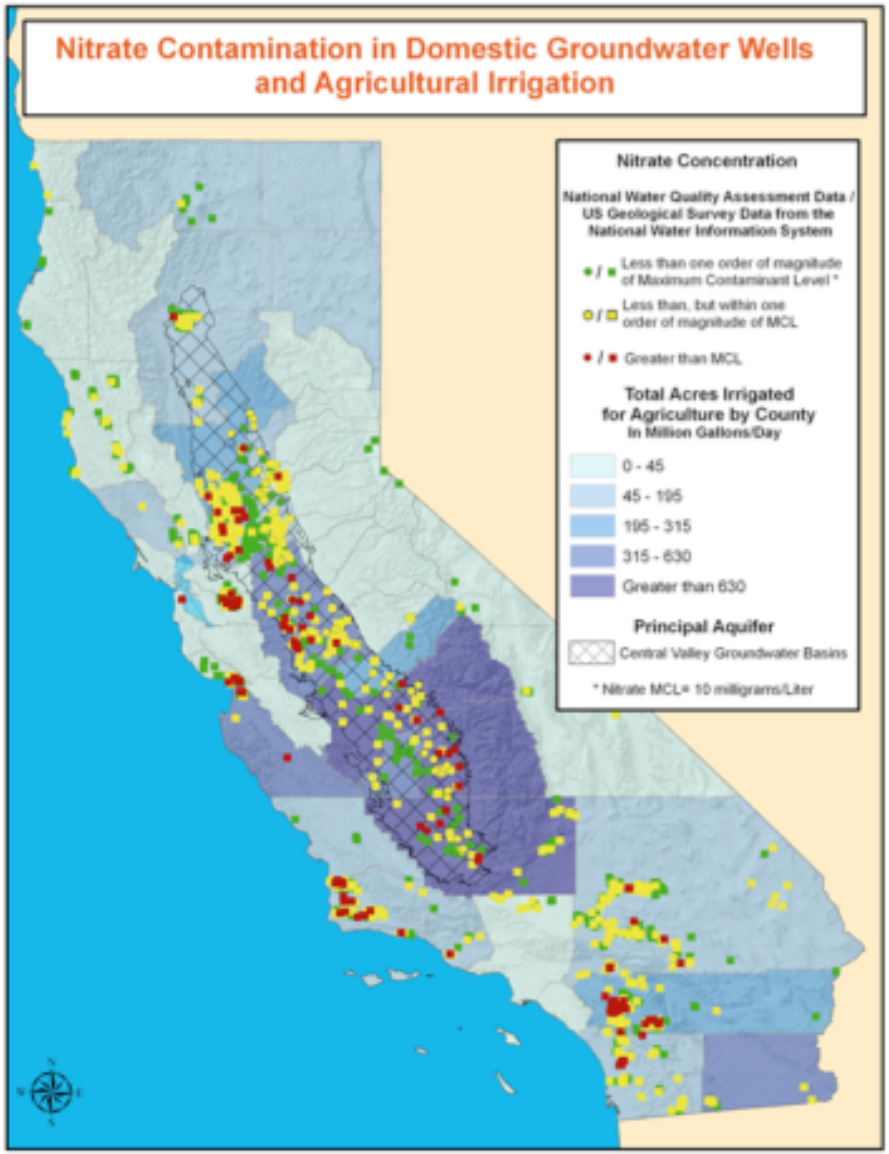
Contextual Legal Issues



Groundwater Pollution

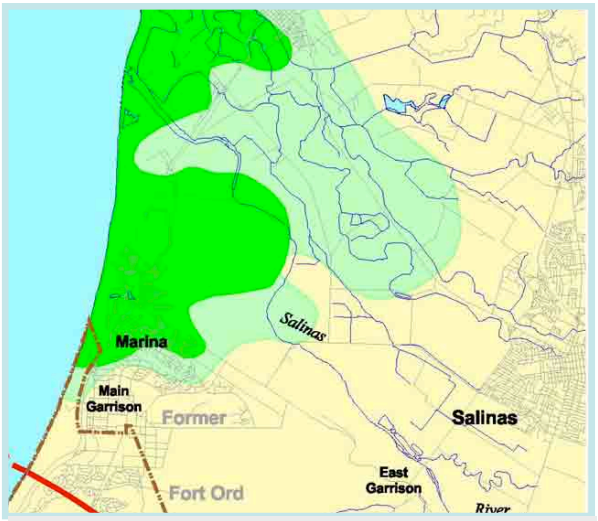
Groundwater sources in violation of safe drinking water standards





Physical Context

Sources of water
Condition of groundwater basin



Seawater Intrusion-Salinas Valley Area

Socio-Political Context

Stakeholder conflicts
Agency/Board leadership

Case Studies

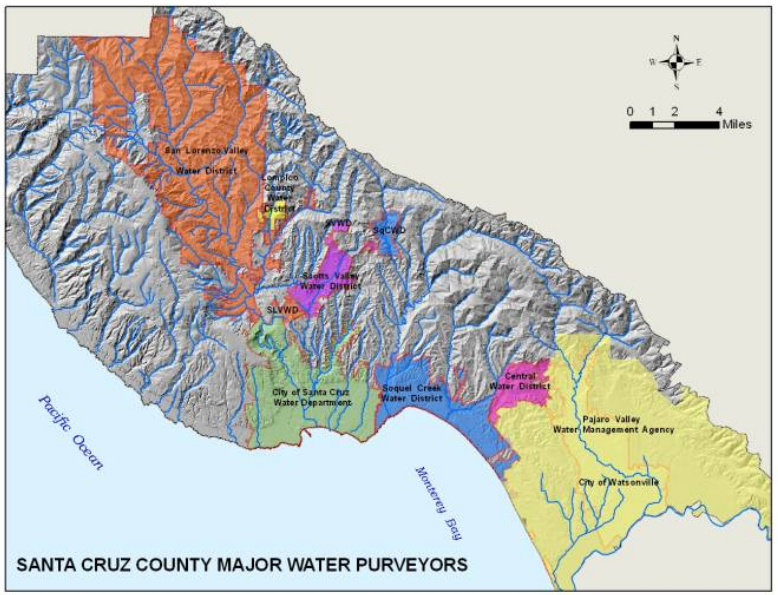
What site-specific factors create an agency's vulnerability to drought and water shortages
and
Influence an agency's drought planning?

Central Coast

North Coast

Scotts Valley Water District

Pajaro Valley Water Management Agency



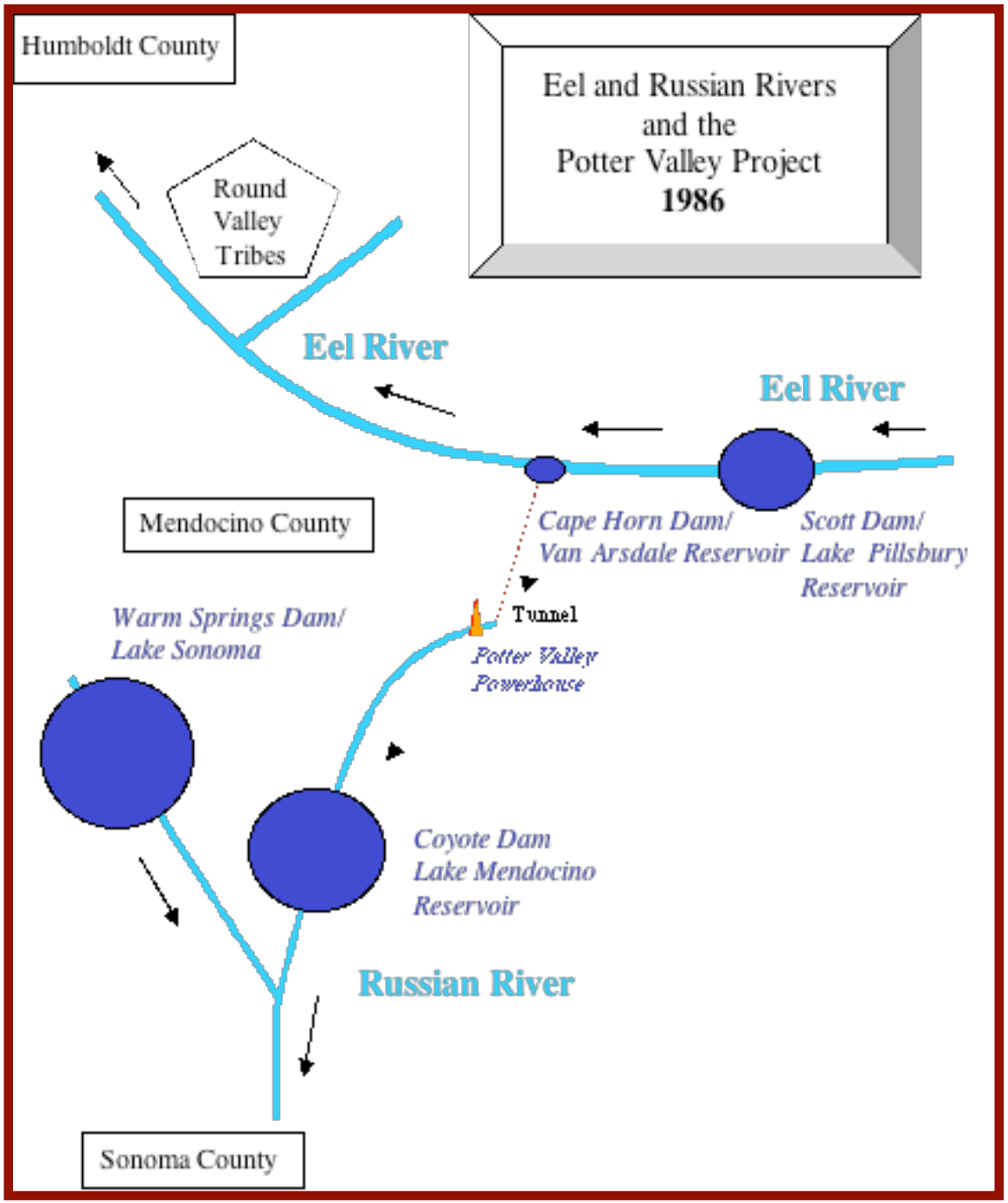
Santa Cruz Water Department

Soquel Creek Water District

Sonoma County Water Agency

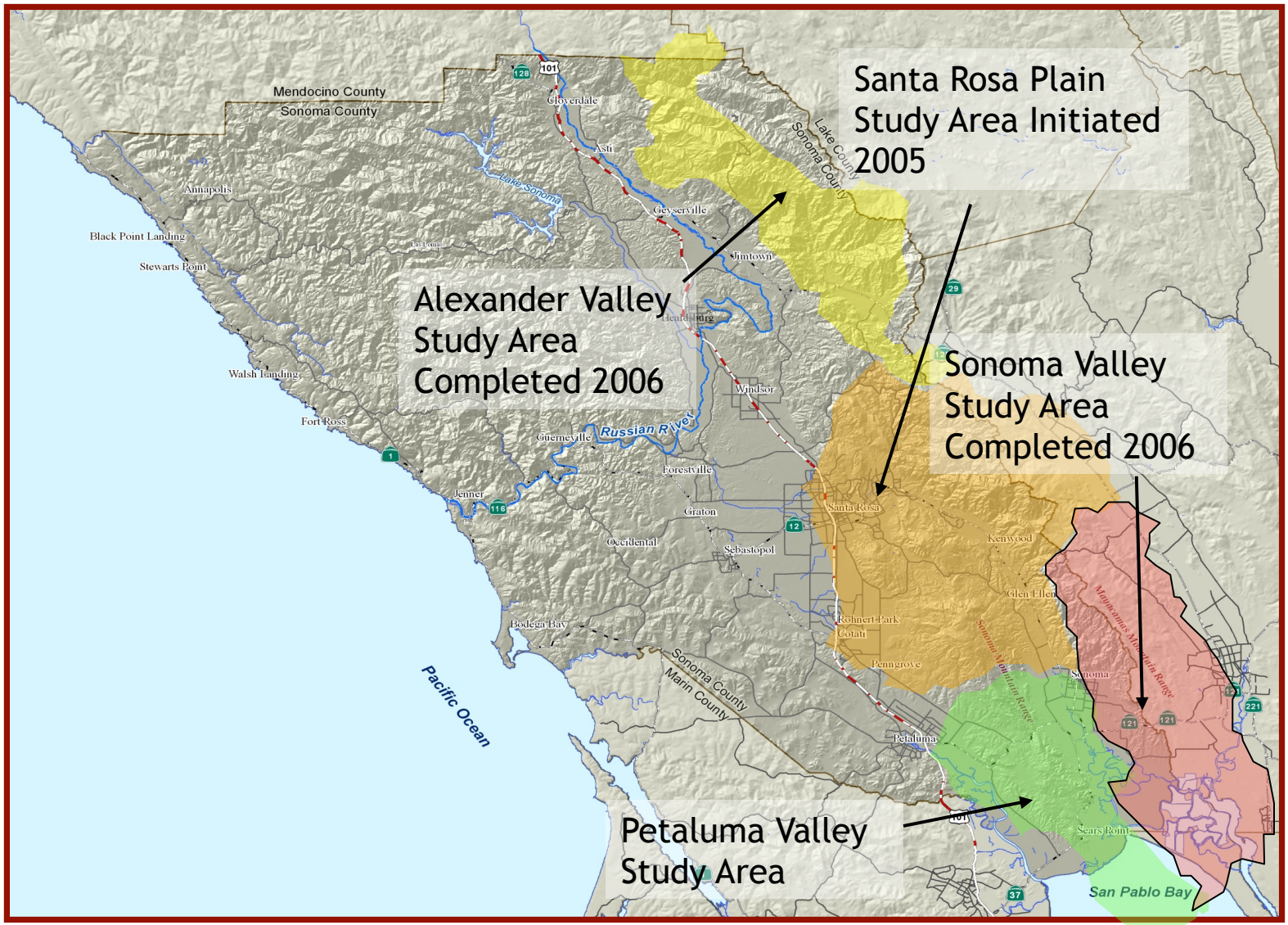
Sonoma County Water Agency

SCWA Surface Water Sources

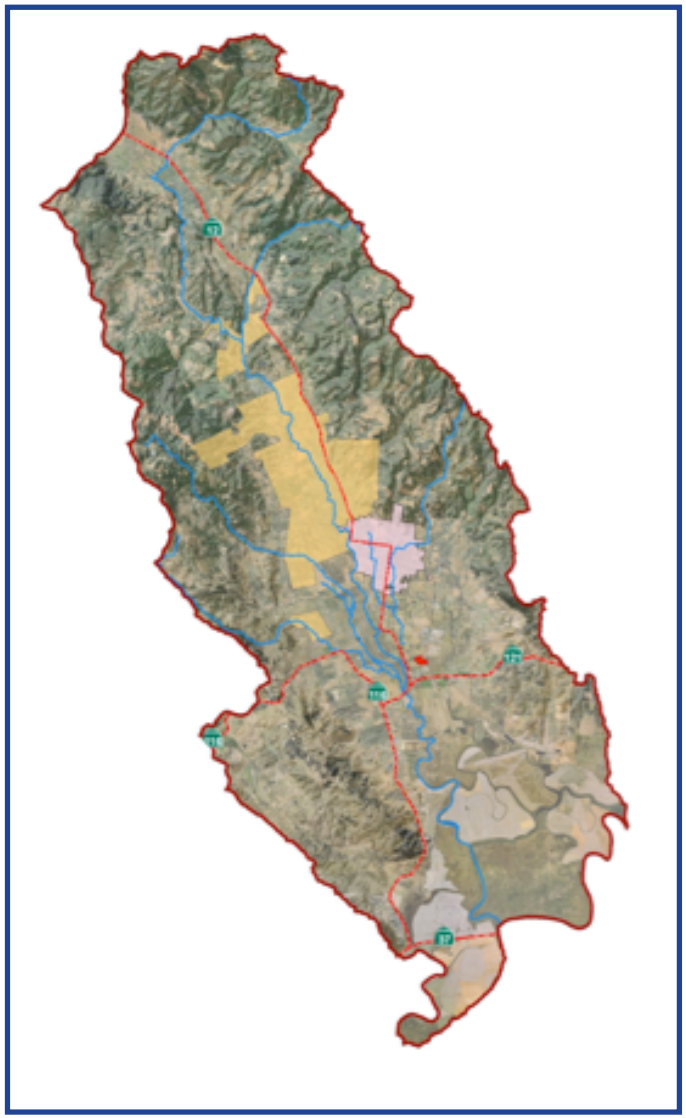


1996	Central California Coastal ESU of Coho Salmon
1997	Southern Oregon/Northern California Coast ESU of Coho Salmon
1999	California Coastal ESU of Chinook Salmon
2000	Northern California Steelhead ESU

SCWA Groundwater Basins



Sonoma Valley Groundwater Management Program



2006: Convened Stakeholder Group

2007: Groundwater Management Plan

Adopted by:

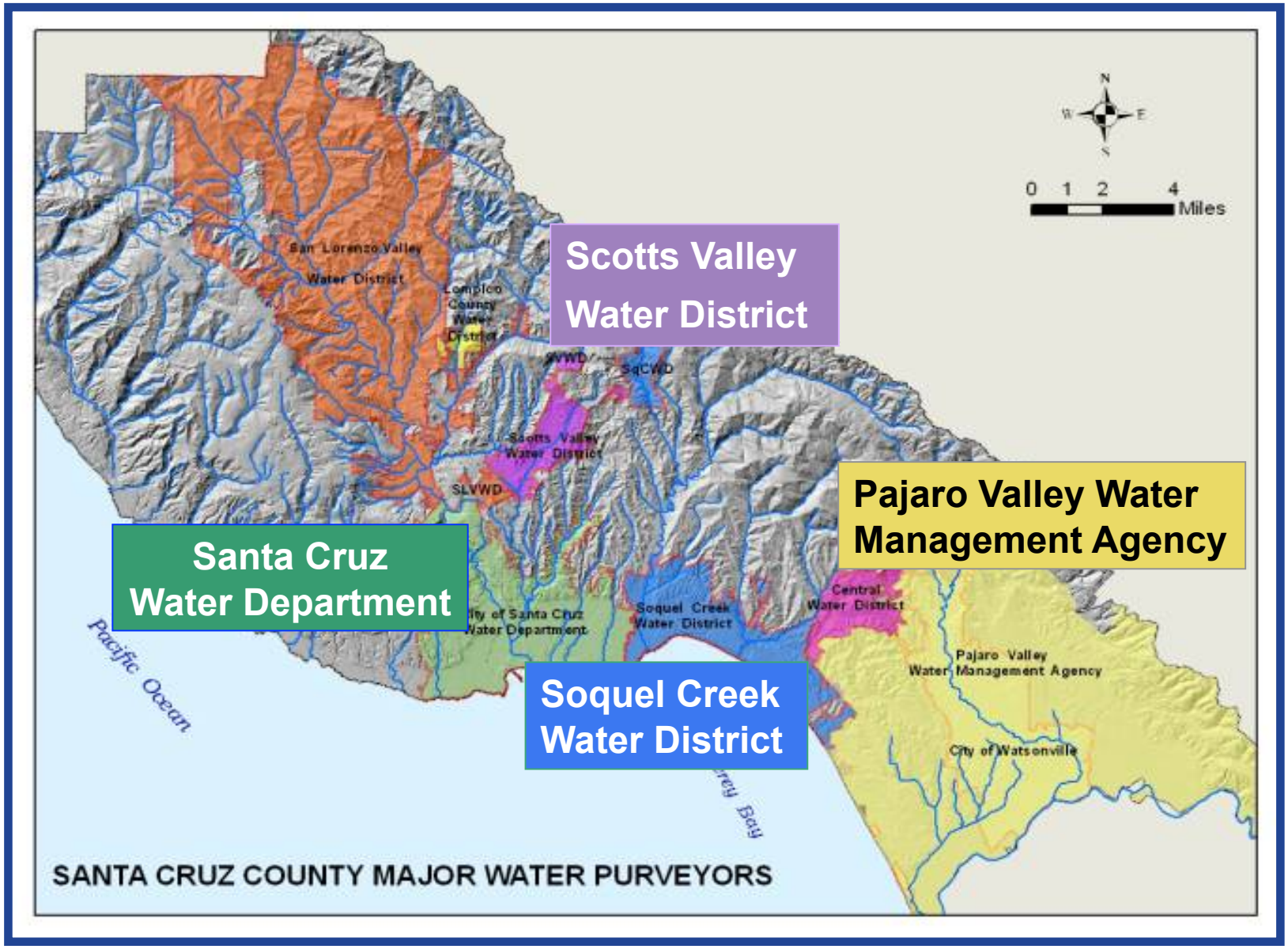
Sonoma County Water Agency

City of Sonoma

Valley of the Moon Water District

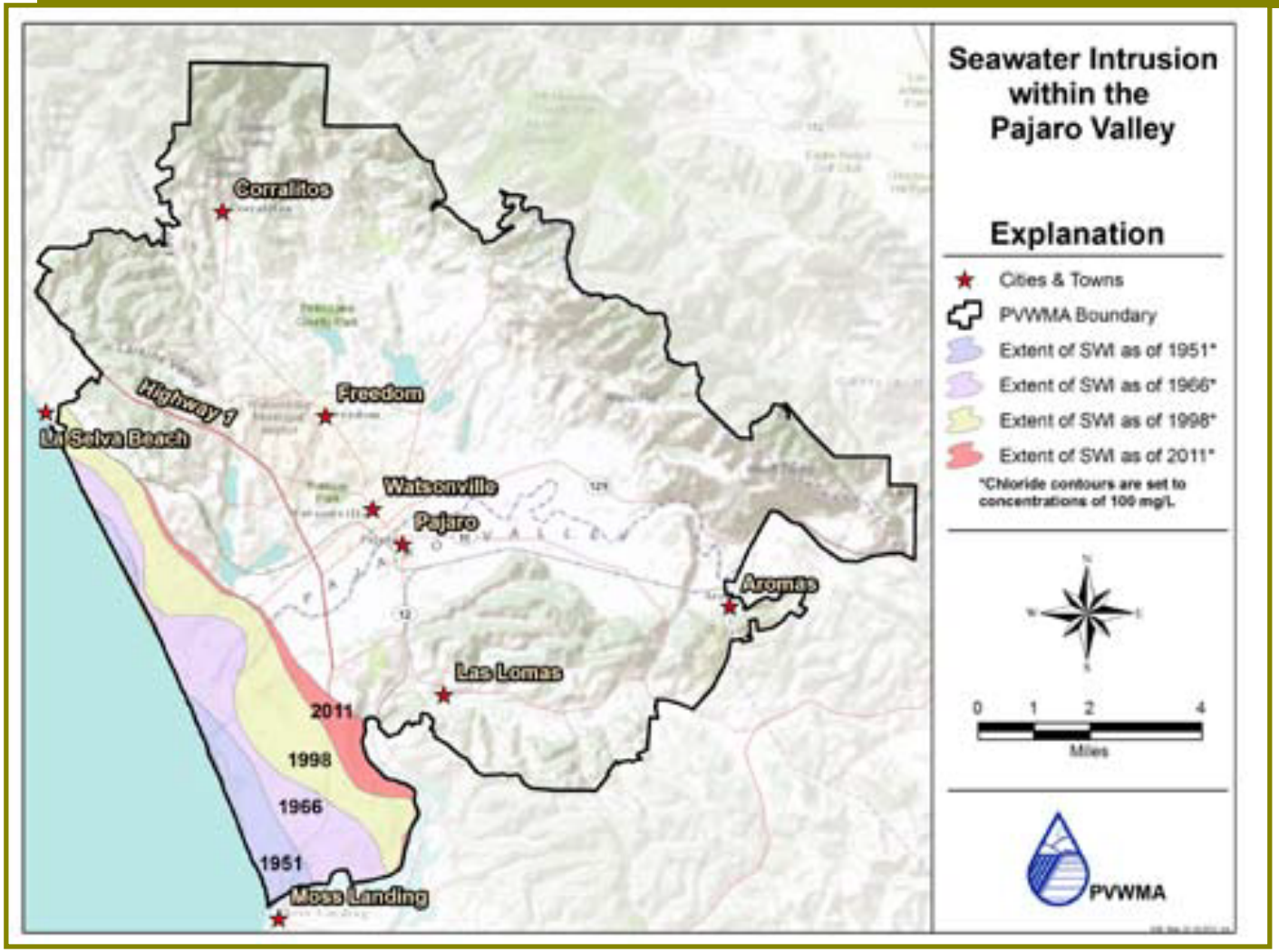
Non-Regulatory and Collaborative Process

Central Coast Study Areas



Pajaro Valley Water Management Agency

Seawater Intrusion = ~ 1,900 afa in Upper and Lower Aromas aquifers



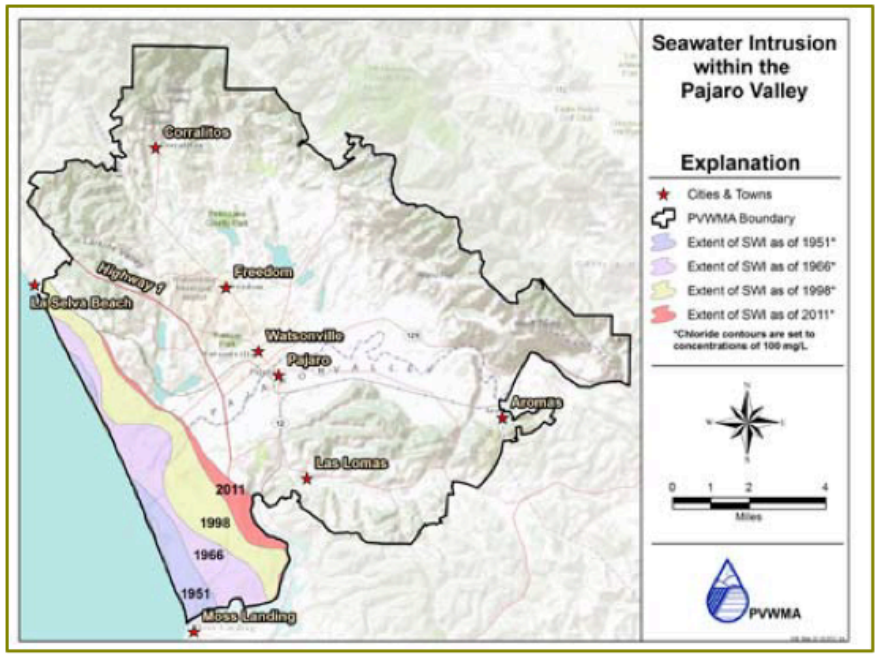
1998-2011
12% increase

Total intruded area has increased ~ sevenfold since 1951

Largest increases in seawater intrusion rates correspond with periods of drought

Pajaro Valley Water Management Agency

Stakeholder Conflicts Litigation

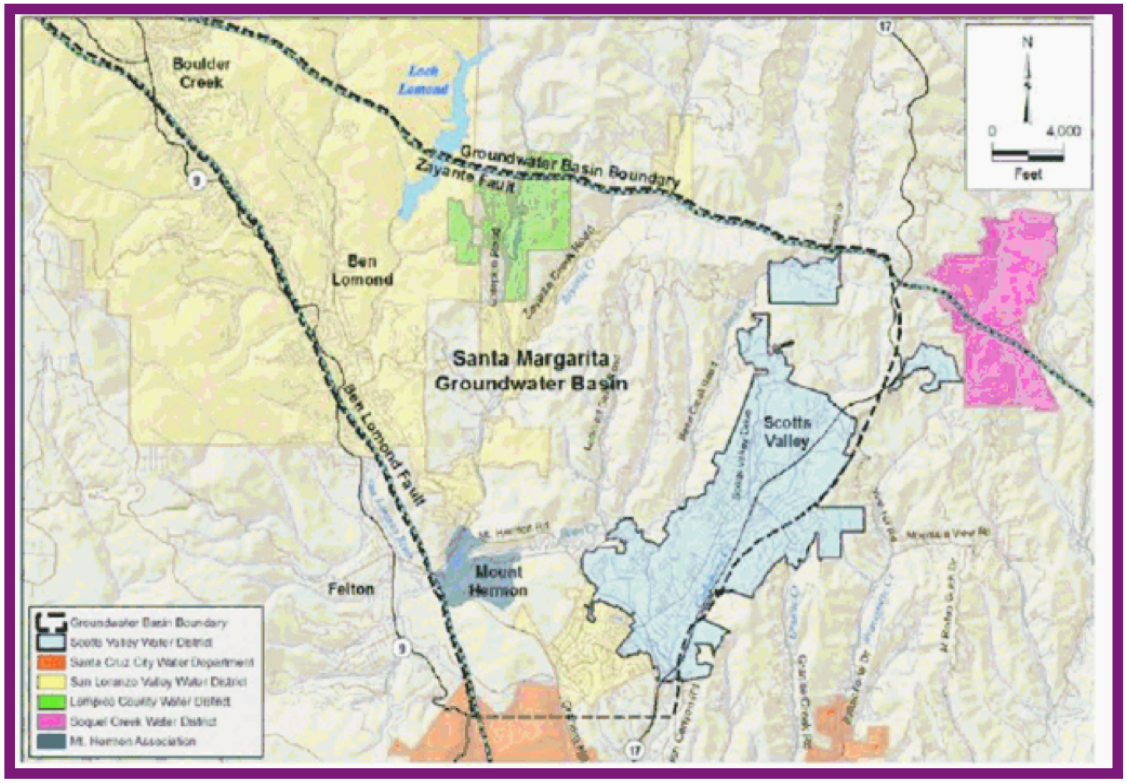


Strategies to Reduce Overdraft

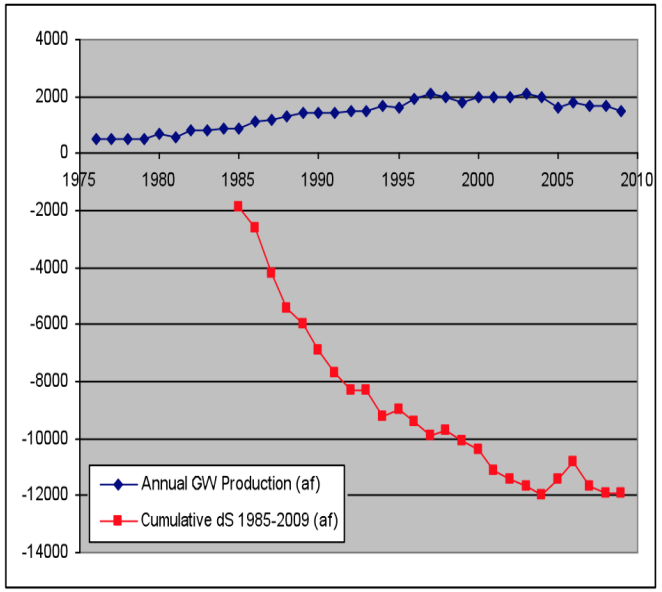
Coastal Distribution System

Recycled Water and Recharge Facilities

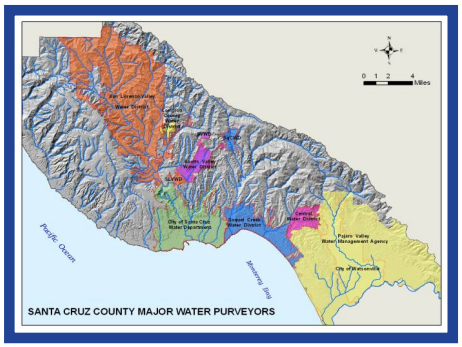
Scotts Valley Water District



Groundwater from
The Santa Margarita
Groundwater Basin
Is sole source of
potable water for SVWD

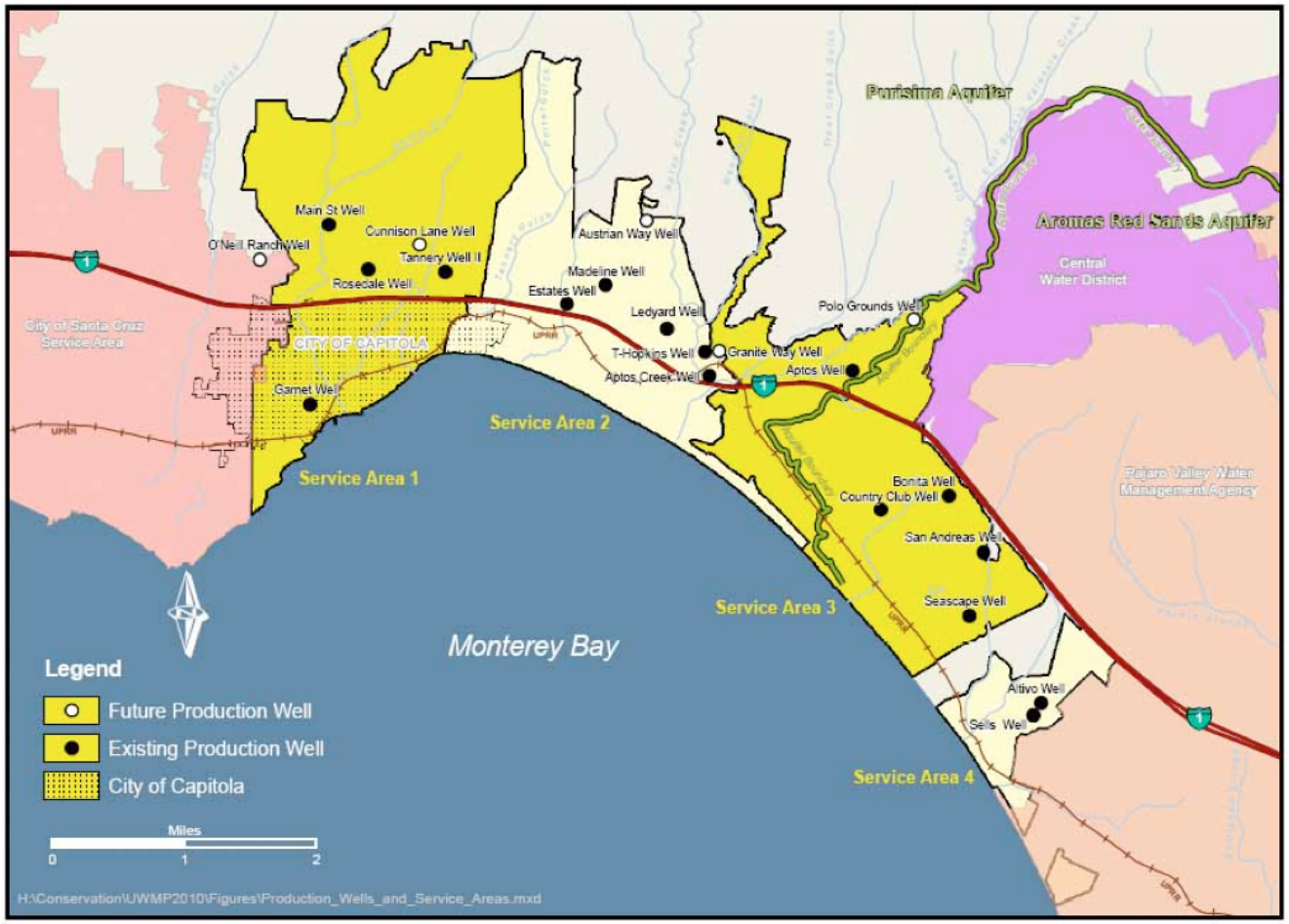


Strategies to Reduce
GW Production
Water Conservation
Recycled Water
Gray Water
Rebates



1975-2010 : Change in
GW Production & Storage

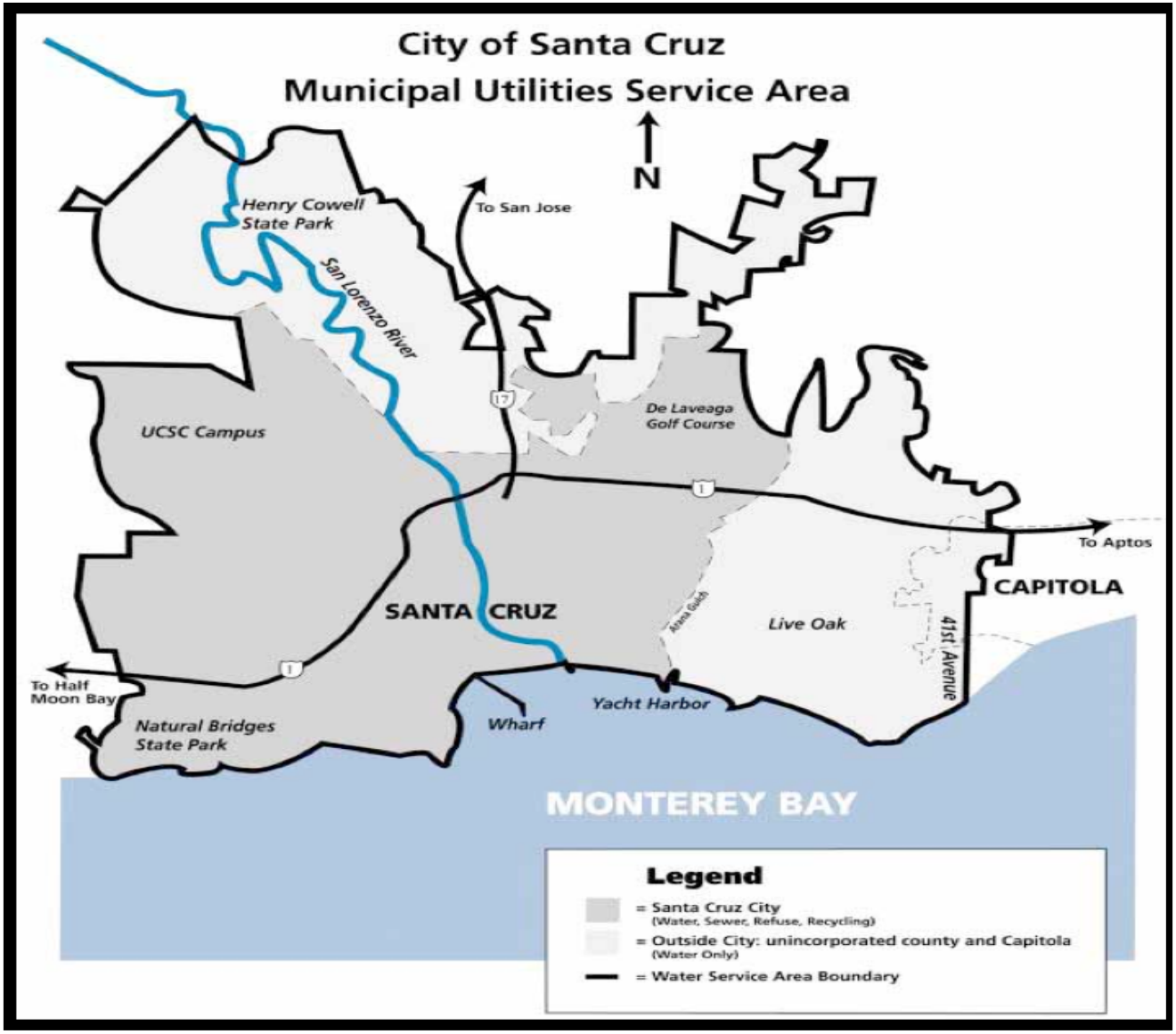
Soquel Creek Water District



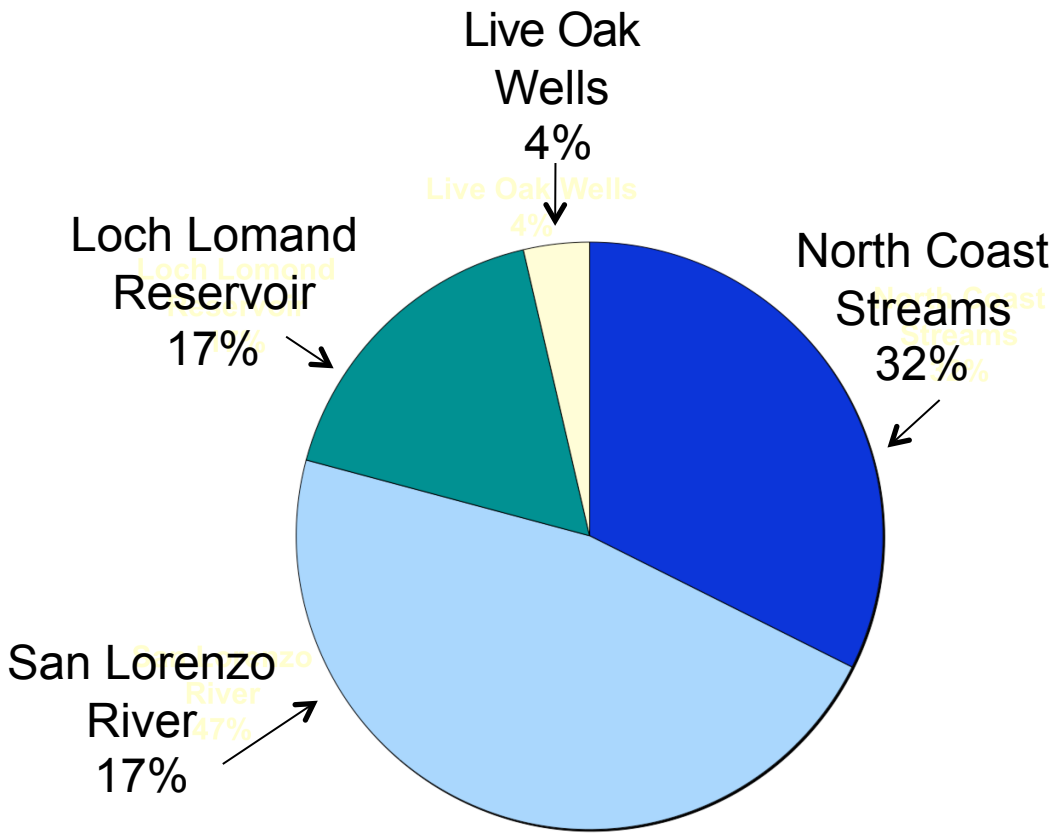
The Purisima Aquifer provides 2/3 of SqCWD's water and is at risk for seawater intrusion

The Aromas Red Sands Aquifer provides 1/3 of SqCWD's water and is at risk for further seawater intrusion

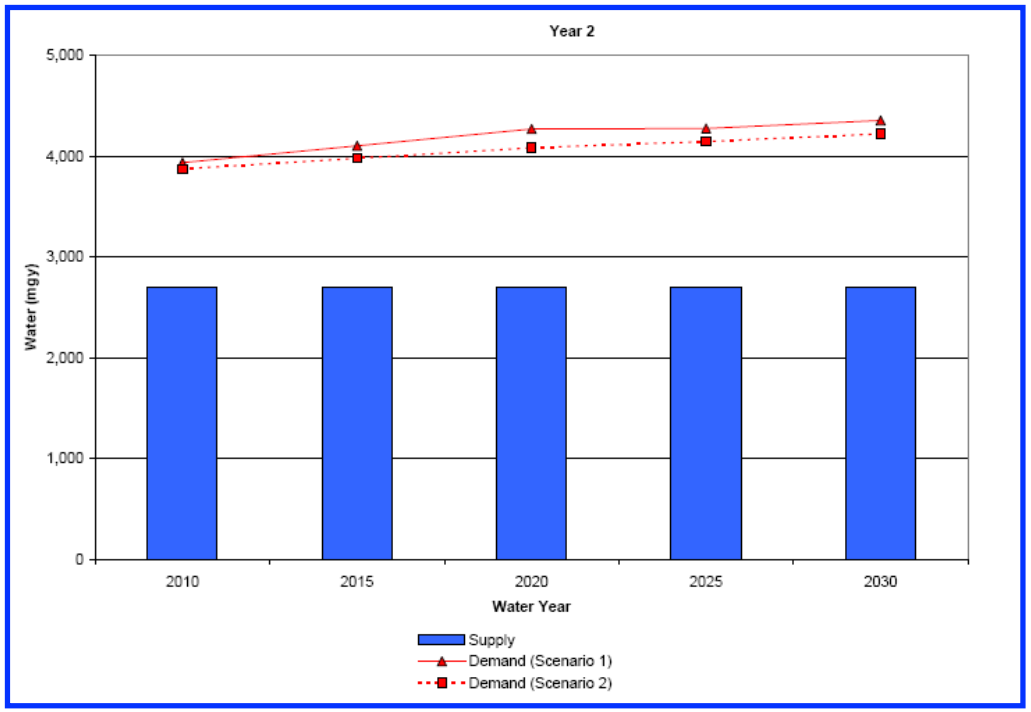
Santa Cruz Water Department



Percent of Total Water Production by Source



Multiple Dry Water Years



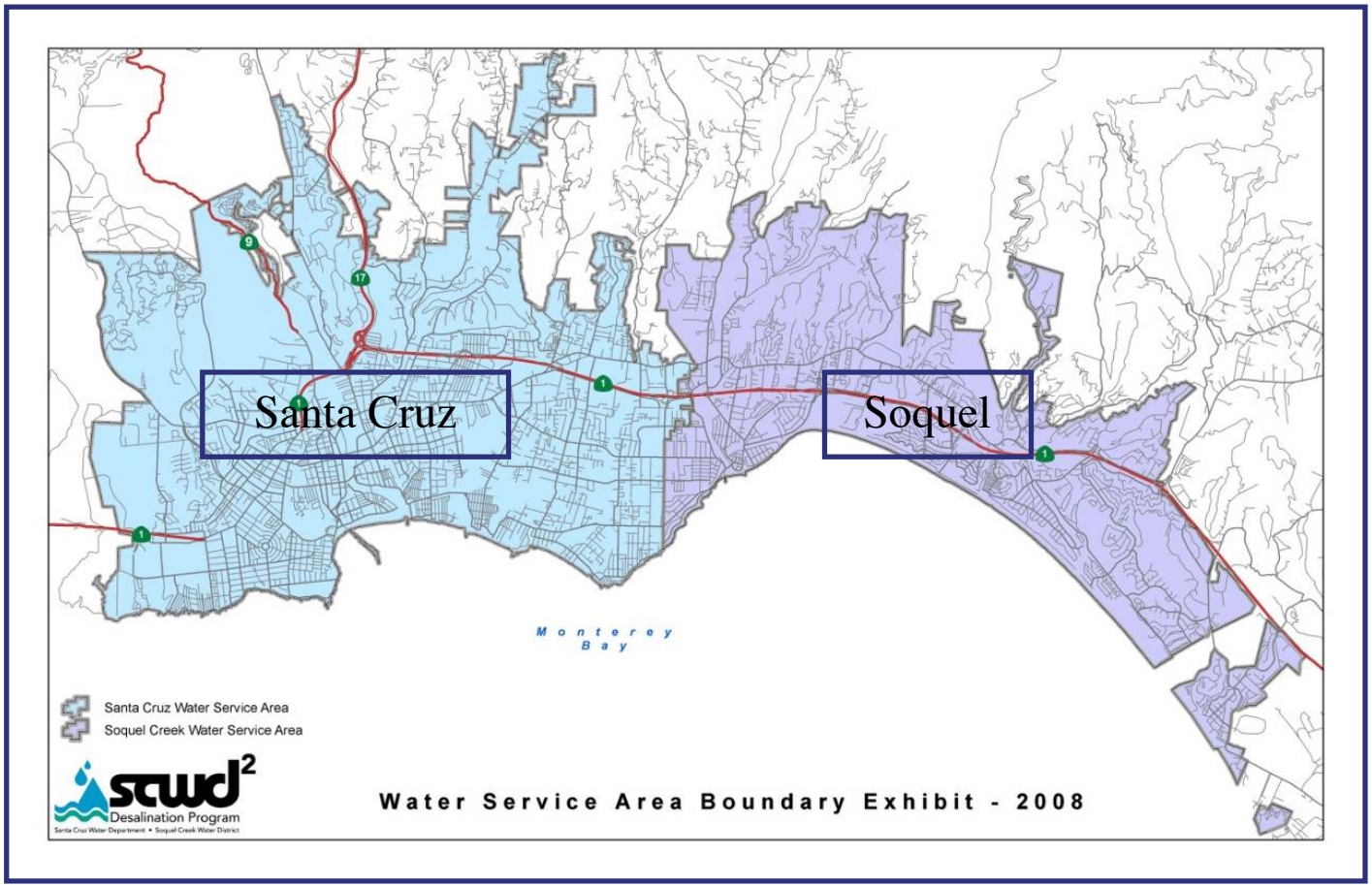
Endangered Species

CA Fish and Game pressure to reduce existing surface water diversions for endangered salmon and steelhead

Drought Reserve Project

Desalination Plant

Collaboration Between
Santa Cruz Water Department
and Soquel Creek Water District



Mapping Potential Resilience to Drought

	Sonoma	Pajaro	Santa Cruz	Soquel Creek	Scotts Valley
Physical	Multiple GW + SW sources	GW overdraft Seawater intrusion	Limited SW storage	GW levels declining	GW levels declined - now stable
Socio-Political, Legal Drivers	ESA Agency leadership	Stakeholder conflicts	ESA	Moratorium threat Board leadership	Moratorium
Vulnerability	LOW	LOW to HIGH	HIGH	MEDIUM	LOW
Adaptation Strategy	Diversify sources	Reduce overdraft	*Desal-Drought reserve*	*Desal-Drought reserve*	Conserve
***Potential* Resilience**	HIGH	MEDIUM-LOW	HIGH	HIGH	MEDIUM

*GW – ground water *SW – surface water

Outline Decision Support Tools

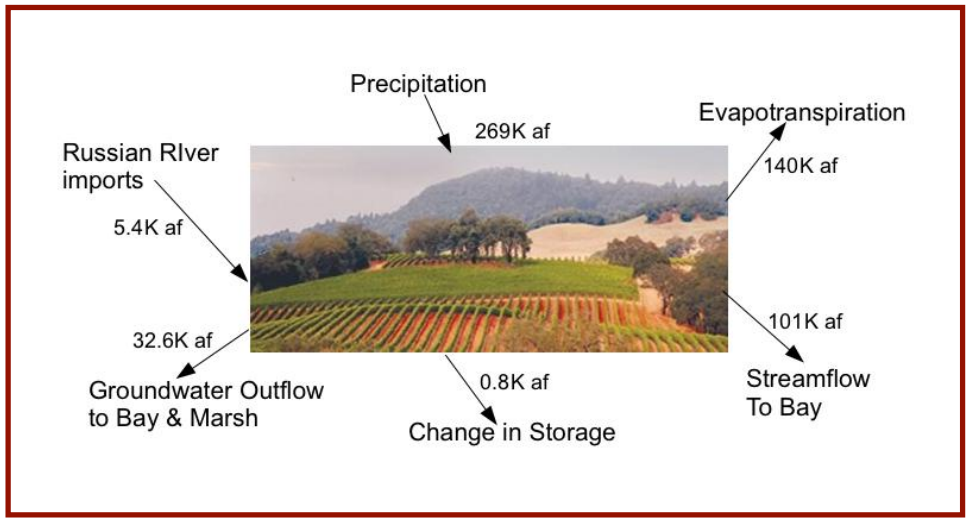
Assisting Water Agencies in Planning a Drought Reserve

Estimate storage capacity of a basin
Calculate groundwater levels to bring basin into hydrologic balance
Determine groundwater levels to sustain a reserve
Determine criteria to access a drought reserve supply

Estimate relationship between rainfall & deep groundwater recharge
Determine drought curtailment criteria for groundwater dependent regions

Sonoma Valley

Calculating a Drought Reserve for Sonoma Valley



Water Balance Model
Sonoma Valley
Source: USGS 2006

For a specified drought, assume:

- Reduction in surface supplies
- GW pumped as usual

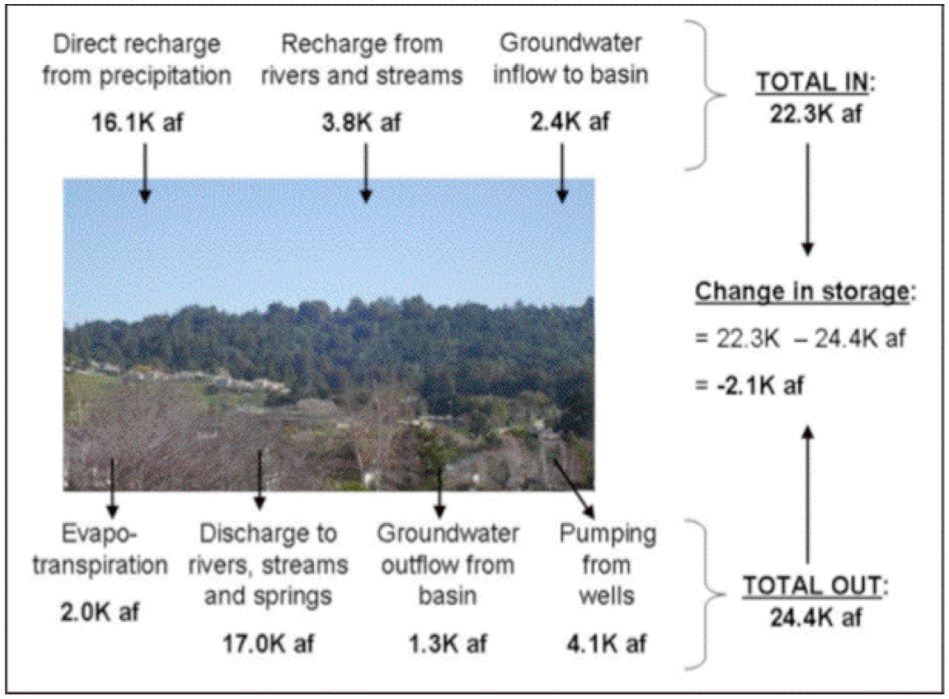
Calculate reduced supply (RS)

- Curtailment requirements

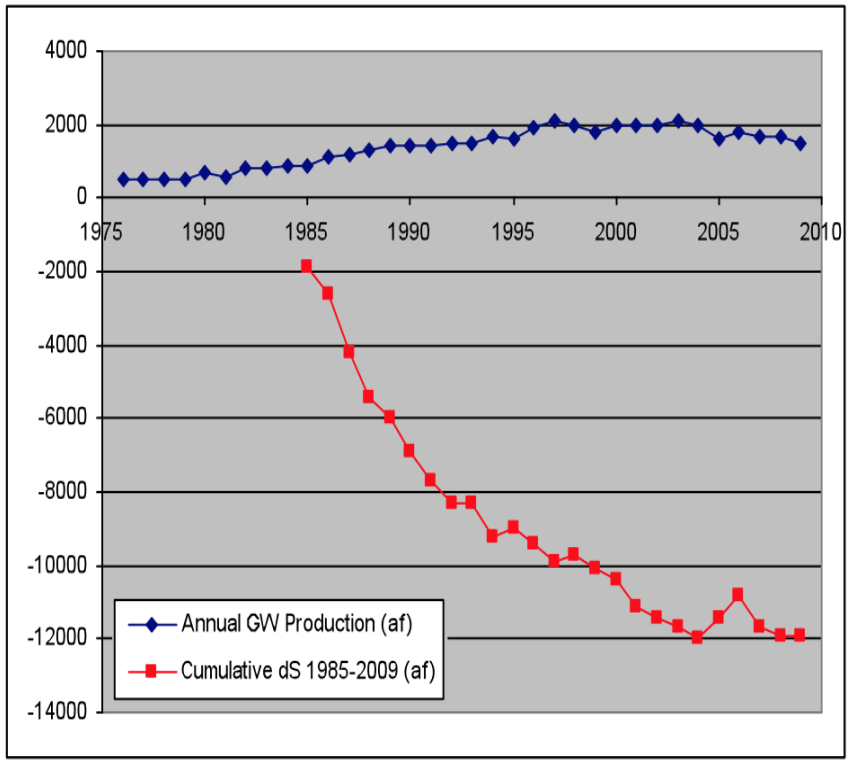
Calculate demand savings (DS)

RS - DS = Potential reserve

Calculating a Drought Reserve for Scotts Valley



Water Balance for Scotts Valley
Source: ETIC Engineering, Inc., May 2006



Safe (Sustainable) Yield

Amount of water an aquifer can yield without depletion

Maximum quantity that can be withdrawn without an undesirable result

Amount of groundwater use based on social **and** hydrologic conditions

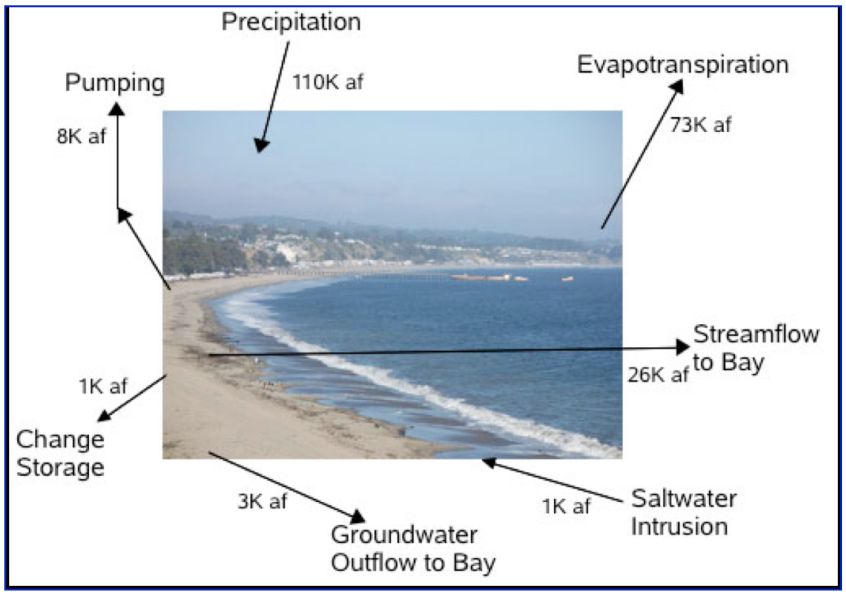
Overdraft

When water being pumped exceeds “safe yield” of the basin

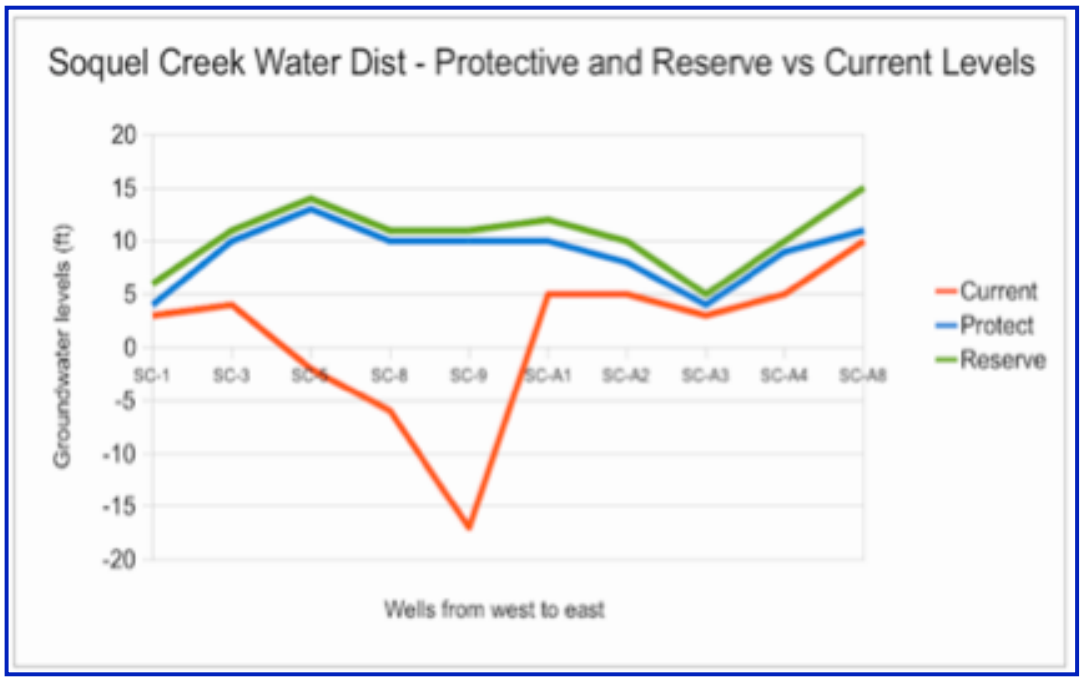
Groundwater levels decline over time and never fully recover

When bad things happen: salt water intrusion, streams go dry, subsidence

Calculating a Drought Reserve for Soquel Creek



Water Balance Model Soquel Creek
Source: Daniels (2011)
Figures from: SqCWD. 2004 & 2009



Source: Data from Soquel Creek Water District. 2009.
Groundwater level metrics can be converted into acre-feet

Improving Drought Planning

What Agencies Are Doing

Water Neutrality Program
Rebates for Conservation
Awards for Demand Reduction
Promotion of Recharge
Cooperative Partnerships

What More Can Be Done

Incorporate goal of establishing drought reserves into planning documents
County incentives
Modernize groundwater law

State Incentives

New Directions

Factors that motivate regions with long-term overdraft and conflicts over water to proactively address drought

Impacts and financial costs and benefits of a groundwater drought reserve versus a no-reserve option

Further development of tools to assist regions in determining thresholds and other parameters for a reserve

“California can no longer ignore the consequences of a potential severe drought, and solutions must move beyond the general notion ….. of reducing water use when a drought occurs.”

Editorial: Slowly, Sacramento Bee 6/3/08